ENGINEERING STATEMENT
IN SUPPORT OF COMMENTS OF THE
ASSOCIATION FOR MAXIMUM SERVICE TELEVISION
IN RESPONSE TO THE NOTICE OF INQUIRY IN THE MATTER OF
TECHNICAL STANDARDS FOR DETERMINING ELIGIBILITY FOR
SATELLITE-DELIVERED NETWORK SIGNALS PURSUANT TO THE SATELLITE
HOME VIEWER EXTENSION AND REAUTHORIZATION ACT
ET DOCKET NO. 05-182

1. Introduction

This engineering statement was prepared on behalf the Association for Maximum Service Television ("MSTV") in support of its comments in response to the FCC's Notice of Inquiry ("NOI") in the matter of *Technical Standards for Determining Eligibility For Satellite-Delivered Network Signals Pursuant to the Satellite Home Viewer Extension and Reauthorization Act* ("SHVERA"), ET Docket No. 05-182. In the NOI, the Commission sought comments and information on whether the signals strength standards of 47 CFR 73.622(e) and the measurement procedures of 47 CFR 73.686(d) should be amended for the purpose of identifying if a household is unserved by a digital television signal and thus eligible for reception of a retransmitted distant network signal.

For the purposes of predicting whether a household is unserved by a DTV signal, MSTV believes that the Commission should not change the signal strength standards of 47 CFR 73.622(e). These standards were established in the Sixth Report and Order in MM Docket No. 87-268, Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, FCC 97-115 (herein "DTV Sixth R&O"), and incorporated into Rule Section 73.622(e). As the NOI indicates, the signal strengths specified in Section 73.622(e) are expressed as the electric field strengths necessary at a receiving antenna to provide a signal sufficient to overcome the thermal and receiver noise present within the 6 MHz DTV channel to provide an acceptable picture on a DTV receiver, and thus they are termed the "noise-limited field strengths."

The noise limited field strength values listed in Section 73.622(e) are based on a set of planning factors recommended by FCC Advisory Committee on Advanced Television Service and are listed in Appendix A of the DTV Sixth R&O. This engineering statement reviews the bases for these planning factors and provides examples of specifications for available equipment demonstrating that the planning factors remain an appropriate means of defining digital television service availability.

2. DTV Planning Factors

The DTV planning factors, as listed in the DTV Sixth R&O, are provided in Table 1 below. Following the table are detailed descriptions of each factor including a summary of the parameters upon which each factor is based.

Table 1 – DTV Planning Factors[1]

Planning Factor	Low VHF	High VHF	UHF	Units
	Ch. 2-6	Ch. 7-13	Ch. 14-69	
Geometric Mean Frequency	69	194	615	MHz
Dipole Factor (dBm-dBu)	-111.8	-120.8	-130.8	dB
Thermal Noise	-106.2	-106.2	-106.2	dBm
Antenna Gain	4	6	10	dBd
Downlead Line Loss	1	2	4	dB
Antenna front-to-back ratio	10	12	14	dB
Receiver Noise Figure	10	10	7	dB
Time Probability Factor (90% Availability)	0	0	0	dB
Location Probability Factor (50% Availability)	0	0	0	dB
C/N Ratio	15.2	15.2	15.2	dB
Noise-Limited Field Strength	28	36	41	dBuV/m, f(50,90)

The DTV planning factors were listed in an alternate form in the Satellite Home Viewer Improvement Act (SHVIA) proceedings[2]. So that there is no confusion, where appropriate we provide an explanation of the differences in form. No matter which form

[1] From Sixth Report and Order, Appendix A, *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket No. 87-268, FCC 97-115.
[2] See Report, *Technical Standards for Determining Eligibility for Satellite-Delivered Network Signals Pursuant to the Satellite Home Viewer Improvement Act*, ET Docket No. 00-90, FCC 00-416.

is used to express the DTV planning factors, the noise-limited field strengths calculated from them are the same.

2.1 Use of Geometric Mean Frequency

For DTV planning purposes, a frequency dependent dipole factor was calculated for the three television bands (Low VHF, High VHF and UHF) based on the geometric mean of the frequencies at the upper and lower edges of each band. The geometric mean frequency was then used to calculate a single dipole factor for each of the three television bands, thus simplifying the planning process by eliminating the need to separately calculate a dipole factor for each DTV channel. Absent this policy, the calculated noise-limited signal strengths would vary in a frequency-dependent manner from channel to channel across the entire band. The use of the geometric mean frequency is reasonable for planning purposes as differences between the dipole factor as calculated based on the geometric mean frequency and that calculated based on the center frequency of the actual channels are small (1 to 2 dB, depending on band).

2.2 Dipole Factor

The dipole factor expresses the quantitative relationship between the power or voltage present at the terminals of a half-wave dipole antenna which is immersed in an electric field of known strength. The DTV Sixth R&O expresses the dipole factor in logarithmic form as the relationship between electric field strength and power. The SHVIA Report expresses the dipole factor in logarithmic form as the relationship between electric field strength and voltage. Both the DTV Sixth R&O and the SHVIA Report assume a 75-ohm load. It is important to note that no substantive differences arise from the variation in the form of expressing the dipole factor.

2.3 Thermal Noise

For the DTV planning factors, thermal noise is calculated based on a 6 MHz-wide channel and assumed temperature of 290K. The DTV Sixth R&O expresses it in logarithmic terms as power in decibels relative to a milliwatt. The SHVIA Report expresses it in logarithmic terms as voltage in decibels relative to a microvolt, assuming a 75-ohm impedance.

We note that the DTV Sixth R&O correctly reports the thermal noise at -106.2 dBm. When expressed in terms of voltage in units of dB/1µV for a 75-ohm impedance the value is 2.56 dB/1µV. It is not known why the thermal noise is reported as 1.75 dB/1µV in the SHVIA Report. The 0.81 dB of difference does not result in a change in the noise-limited field strengths in the SHVIA Report due to the fact that the SHVIA Report adjusts the Carrier-to-Noise ratio by 0.8 dB (15.2 to 16 dB) from that used in the DTV planning factors in the DTV Sixth R&O. This compensates for the difference in the reported thermal noise figure.

2.4 Antenna Gain and Downlead Line Loss

In both the DTV Sixth R&O and the SHVIA Report, the presumed antenna gains are expressed in decibels relative to a half-wave dipole and the downlead line losses are expressed based on assumed use of 50 feet of typical 75-ohm coaxial cable.

2.5 Antenna Front-to-Back Ratio

The antenna front-to-back ratio, which is listed in the DTV Sixth R&O (but is not listed in the SHVIA Report) does not enter into the calculations of the noise limited field strengths. It is, however, pertinent to issues of interference from undesired signals, and it is used in the process of allotting DTV channels. The antenna front-to-back ratio expresses the assumed difference between the maximum antenna gain (for an antenna properly oriented toward a desired station) and the gain for the antenna in the opposite direction (180°) to its maximum gain.

2.6 Receiver Noise Figure

The receiver noise figure expresses, in logarithmic terms, the increase in overall noise (above thermal noise) due to internal receiver circuitry. The figures are based on tests conducted on the Grand Alliance system (the 8-VSB system adopted by the FCC for US digital television) at the Advanced Television Test Center and are reported in the "Final Technical Report" of the Technical Subgroup of the FCC Advisory Committee on Advanced Television Service, October 30, 1995.

2.7 Time and Location Probability Factors

For the purpose of predicting the limit of DTV service, the time and location probability factors that were adopted are the same as the planning factors used for the Grade B analog (NTSC) television signal, namely a signal predicted to be received at 50 percent of the locations, 90 percent of the time. Unlike the analog Grade B planning factors, however, no adjustment was made to the DTV noise limited field strengths in terms of a median field (50 percent of the locations, 50 percent of the time) as was done with the Grade B field strength. Rather, the noise limited field strengths for DTV service are expressed as fields received at 50 percent of the locations, 90 percent of the time.

When predicting DTV service based on the noise limited field strength, the prediction model takes into account both the time and location probability factors. Therefore, the values of both factors are 0 dB when predicting the field strengths.

2.8 Carrier-to-Noise (C/N) Ratio

The carrier-to-noise (C/N) ratio is also based on testing done on the Grand Alliance system at the Advanced Television Test Center. The 15.2 dB figure listed in the DTV Sixth R&O expresses the minimum ratio of the desired carrier power to noise power necessary to produce an acceptable DTV picture. In the SHVIA Report, this figure is listed as 16 dB. However, since the SHVIA Report understates the thermal noise by 0.81 dB (see Section 2.3), the net result is no change in the noise-limited field strengths.

3. Applicability of Planning Factors to Equipment Available for Purchase and Installation

For the purpose of evaluating whether the noise limited field strengths, developed based on the DTV planning factors, are still valid based on performance of available receiving equipment, we provide the following information comparing the applicable DTV planning factor values to the values of those factors as specified by manufacturers for equipment that is presently available for purchase and installation.

3.1 Antenna Gain and Front-to-Back Ratio

The planning factors for antenna gain and front-to-back ratio were for outdoor antennas. A search of web sites for suppliers and manufacturers of outdoor antennas reveals the following partial list of antennas (see Table 2) that meet or exceed the antenna gain and front-to-back ratio values contained in the DTV planning factors. The gain and front to back ratios shown in Table 2 were obtained from information produced by the manufacturers and/or equipment suppliers.

Table 2 – Specifications from Manufacturers of Outdoor Receiving Antennas				
Frequency Band	Manufacturer	Antenna Model	Antenna Gain (dBd)	Antenna Front-to-Back Ratio (dB)
Low VHF	Antennacraft	CS-1100	6.9	19.4
	Channel Master (Andrew)	Crossfire Model 3671	5.6 (Band Average) 4.9 (min. Ch 2) 6.2 (max. Chs 5,6)	24 (minimum across band)
	Winegard	Prostar 1000 Model PR-5030	5.0 (min. Ch 4) 7.0 (max. Ch 6)	19 (min. Ch 2)
High VHF	Antennacraft	CS-1100	9.6	17.6
	Channel Master (Andrew)	Crossfire Model 3671	10.9 (Band Average) 9.5 (min. Ch13) 11.5 (max. Ch 8)	14 (minimum across band)
	Winegard	Prostar 1000 Model PR-5030	7.5 (min. Ch 7) 9.5 (max. Ch 9)	13 (min. Ch 7) >20 (max. Ch 4,6)
UHF (Channels 14 –51)	Antennacraft	MXU-59	10.7	17.0
	Channel Master (Andrew)	UHF Model 4228	10.8 (min. Ch 14) 12.7 (max. Ch. 43)	19 (min. Ch 35) 24 (max. Ch. 43)
	Winegard	Prostar 1000 Model 9032	14.9 (min. Ch 14) 16.3 (max. Ch 32)	14 (min. Ch 14) 20 (max. Ch 32,50)

As can be seen in Table 2, with respect to both the antenna gain and antenna front-to-back ratio, the data indicate that there are a number of receiving antennas available on the market that exceed the DTV planning factors.

As an aide in reception, mast-mounted, low-noise pre-amplifiers are available which can further enhance system gain. For reference, relevant specifications for three models are listed in Table 3.

Table 3 – Specifications from Manufacturers of Mast-Mounted Preamps				
Frequency Band	Manufacturer	Amplifier Model	Amplifier Gain (dB)	Amplifier Noise Figure (dB)
VHF	Antennacraft	10G202	29 (avg VHF/UHF)	<3.0 (VHF)
	Channel Master (Andrew)	Titan 2 Model 7777	23	2.8
	Winegard	Chromstar 2000 Model AP-2880	29	2.9

Table 3 – Specifications from Manufacturers of Mast-Mounted Preamps

UHF	Antennacraft	10G202	29 (avg VHF/UHF)	<2.6 (UHF)
	Channel Master (Andrew)	Titan 2 Model 7777	26	2.0
	Winegard	Chromstar 2000 Model AP-2880	19	2.9

When the improvements in system noise figure (see Section 3.3 below) resulting from implementation of a mast-mounted preamplifier are taken into account, it is possible to meet the planning factor gain figures even when using antennas with passive gains less than the planning factor values.

3.2 Downlead Line Loss

The line loss values contained in the DTV planning factors are based on 50 feet of 75-ohm coaxial cable. The planning factor values appear reasonable based on the published attenuation values for 75-ohm RG-6 coaxial cable. Table 4 provides specifications from three different coaxial cable manufacturers. In all three cases, the attenuation values assumed in the DTV planning factors exceed that of available products. In other words, the DTV planning factors use conservative estimates of transmission loss.

Table 4 – Specifications from Manufacturers of Coaxial Cable (75 ohm)

Frequency	Manufacturer	Cable Type and Model	Attenuation (dB/100 ft)	Attenuation (50 feet of cable)
69 MHz (Low VHF)	Belden	RG 6/U Model 9116	1.71	0.86
	Channel Master	RG6 9533-500	1.79	0.90
	Coleman	RG 6/U Model 992127	1.9	0.95
194 MHz (High VHF)	Belden	RG 6/U Model 9116	2.73	1.37
	Channel Master	RG6 9533-500	2.89	1.45
	Coleman	RG 6/U Model 992127	3.2	1.6
615 MHz (UHF)	Belden	RG 6/U Model 9116	5.00	2.50
	Channel Master	RG6 9533-500	5.57	2.79

Table 4 – Specifications from Manufacturers of Coaxial Cable (75 ohm)				
	Coleman	RG 6/U Model 992127	6.2	3.1

3.3 Receiver Noise Figure

The receiver noise figures used in the planning factors are 10 dB for low-band VHF, 10 dB for high-band VHF and 7 dB for UHF, based upon test data from the Advanced Television Test Center. We have not independently tested a representative sample of DTV receivers, and since the Commission has stated in the NOI that it intends to conduct measurements on DTV receivers, we assume that the Commission will be drawing conclusions regarding the appropriate noise figure values for the purposes of the SHVERA. We note that analog (NTSC) UHF receivers have achieved noise figures in the range of 7 to 8 dB.

It is noted that the overall system noise figure can be significantly reduced with the use of a high-gain, low-noise, mast-mounted pre-amplifier. For example, assuming a mast-mounted, pre-amplifier gain of 19 dB with noise figure of 2.9 dB at UHF frequencies (based on values contained in Table 3), and assuming a downlead line loss of 4 dB and receiver noise figure of 7 dB per the DTV UHF planning factors, there is a calculated improvement in the overall system noise figure of 7.8 dB.

3.4 Receiver C/N Ratio

Laboratory measurements on various DTV receivers were reported by Bouchard, et al. of the Communications Research Center Canada (CRC) in late 2000.[3] These measurements demonstrated C/N levels consistent with the FCC planning factor of 15.2 dB. The measurements were conducted on six DTV receivers manufactured in the period of 1999-2000. For a weak desired signal level, the results demonstrated a C/N range of 15.3 dB to 17.8 dB, with a median C/N of 15.6 dB. The five best out of the six had a C/N of 15.3 dB to 16.7 dB, with a median C/N of 15.4 dB. The worst performing receiver was the oldest of the population measured.

Recent laboratory measurements on a “fifth generation” DTV receiver also show C/N measurement results consistent with the FCC planning factor. Laboratory measurements were conducted by the CRC on the latest Zenith receiver in September

[3] See Bouchard, Pierre, et al., “Digital Television Test Results – Phase 1”, Communications Research Center (Ottawa, Canada), *CRC Report No. CRC-RP-2000-11*, November 2000.

2003.[4] These results showed a measured C/N of 15.9 dB in the presence of a weak signal level. This is within 0.7 dB of the planning factor figure and indicates that the latest generation of DTV receivers will perform in line with those of earlier manufacture.

3.5 Antenna Orientation

The DTV planning factors assume that the receiving antenna is properly oriented toward the desired station. In the SHVIA proceeding, the Commission affirmed the validity of this assumption with respect to reception of an analog TV signal. Channel Master (now owned by Andrew), Winegard and Delhi (formerly Jerrold) all manufacture antenna rotators for outdoor mast-mounted home antennas. All have control systems that may be operated inside the home to remotely actuate the rotator. The same assumption of proper antenna orientation, as affirmed in the SHVIA proceeding, is also valid for reception of DTV signals, and is therefore consistent with the DTV planning factors.

4. Other DTV Receiver Performance Factors

The NOI requests information on DTV receiver performance as it may be affected by conditions not addressed by the planning factors. Among these conditions is performance in the presence of multipath. With regard to multipath conditions, we note that recent studies on "fifth generation", 8-VSB receivers have shown significant improvement over the performance of earlier receivers.[5]

In Laud's paper, he reports laboratory tests demonstrating fifth generation receiver equalizer capability to handle up to 50-μs pre- and post-ghosts. He also indicates significant improvement in ghost-canceling capability of fifth generation receiver equalizers, with a capable of handling ghost ensembles with up to 100 percent ghosts. His paper also reports on field tests on fifth-generation receivers in Washington, DC; Ottawa, Canada; and Baltimore, MD where significant improvement in performance of fifth generation receivers at known "difficult" locations was demonstrated. In these field tests, fifth generation receivers showed improvements ranging from an elimination to near elimination of failures (in the Ottawa and Baltimore tests) to a reduction in failures by a factor of three (in the Washington tests).

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[4] See "Results of the Laboratory Evaluation of Zenith 5th Generation VSB Television Receiver for Terrestrial Broadcasting", Report Version 1.1, Communications Reseach Centre Canada, September 2003.
[5] See Tim Laud, et. al., "Performance of 5th Generation 8-VSB Receivers", IEEE Transactions of Consumer Electronics, Vol. 50, No. 4, Nov. 2004. Also Yiyan Wu, et. al., "An ATSC DTV Receiver With Improved Robustness to Multipath and Distributed Transmission Environments", IEEE Transactions on Broadcasting, Vol. 50, No. 1, March 2004.

5. Conclusion

In light of the foregoing information on performance of DTV reception equipment, we conclude that equipment is available that will permit DTV reception in the presence of a signal equaling or exceeding that based on the DTV planning factors. Therefore, use of the DTV noise-limited signal strengths, developed based on those planning factors and contained in the DTV Sixth R&O, is an appropriate metric for predicting DTV service under the terms of the SHVERA.

This statement was prepared by me or under my direction and it is true and correct to the best of my knowledge and belief.

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